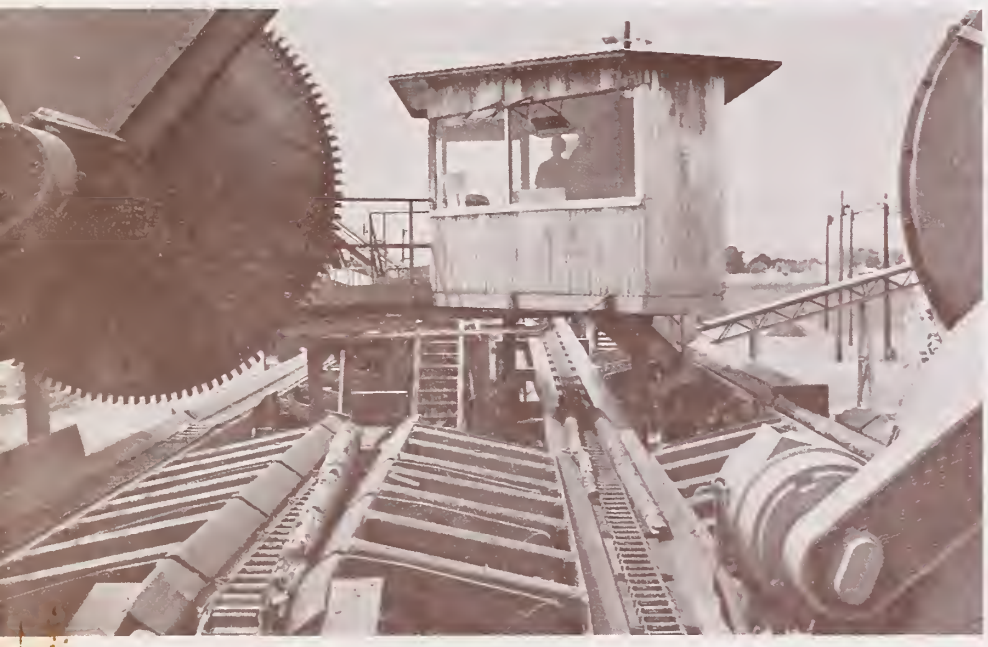

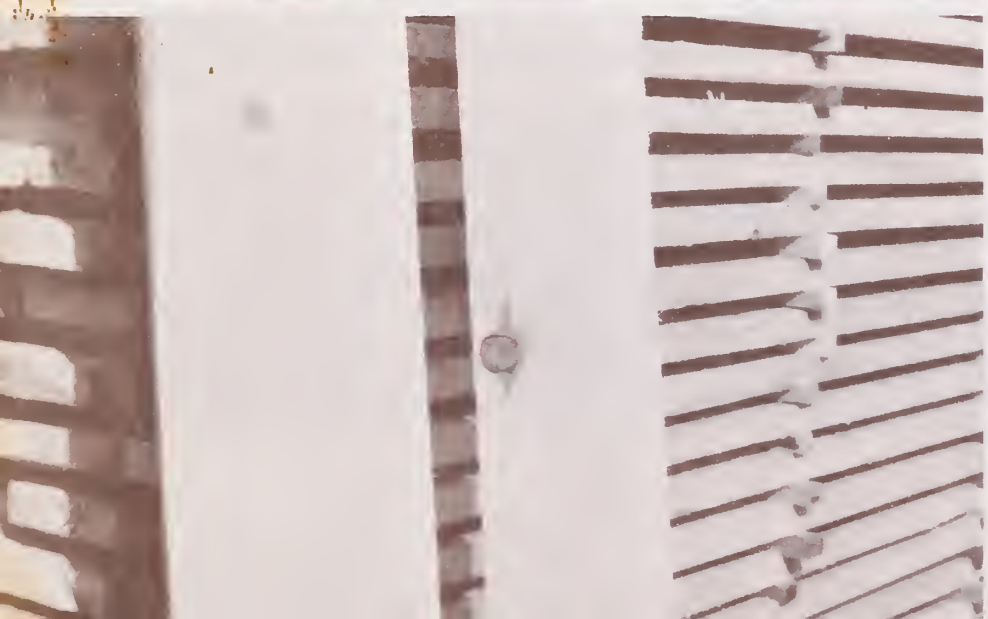

Lumber Yield Potential of Aspen in the Rocky Mountains

Eugene M. Wengert
and
Dennis M. Donnelly

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Lumber Yield Potential of Aspen in the Rocky Mountains[1]

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Abstract

The yield of sawn products from aspen (*Populus tremuloides* Michx.) trees from northern New Mexico and eastern Utah, both in terms of volume and dollar value, was related to trial tree and log grades. Trial grading systems generally allowed separation of trees and logs into different levels of volume and dollar value recovery.

[1]This research was sponsored jointly by the Forest Products Laboratory, the Rocky Mountain Forest and Range Experiment Station, and the Intermountain Forest and Range Experiment Station. Special assistance was provided by R. O. Woodfin, Pacific Northwest Forest and Range Experiment Station; J. Hutt, Carson National Forest; D. Markstrom Rocky Mountain Station; and M. Koepke, Utah Forestry and Fire Control.

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Management Implications

This research attempted to relate lumber recovery to the characteristics of standing aspen timber. Although only limited inferences can be drawn from the results of this preliminary study, it provides valuable insights on the importance of various aspects of lumber volume and grade recovery in relation to visual characteristics of logs and standing trees. This also should be useful in revealing promising approaches to future, more thorough investigations of lumber yield from aspen.

Tree and log grades developed by Bailey (1973, 1974) have some potential for separating aspen trees and logs into value quality classes. Also, value classification based on tree diameter alone works fairly well. Further work will be necessary to confirm the applicability of these findings to aspen timber in other areas and under other utilization objectives. Caution should therefore be used in applying the data shown in tables 5 and 7 to other aspen stands. The data presented here are valid only for the distribution of log sizes sampled in this study, and then only with the reservations associated with small samples. Values can be expected to vary as the distribution of tree and log sizes changes within each grade.

Aspen (*Populus tremuloides* Michx.) is an underutilized species in the Rocky Mountain West. Although recent forest surveys show the Rocky Mountain states have more aspen sawtimber (more than 7 billion fbm of sawtimber) than any other area in the U.S., the annual harvest of this species in the West for sawn products is less than 10 million board feet. For optimum management of the species, annual harvests and utilization for sawn products could be approximately 60 million board feet.

Many factors contribute to this underutilization. One important reason may be widespread unfamiliarity with the possible uses of aspen and, therefore, an inability to assess the utilization potential of standing timber or logs.

One of the most obvious inadequacies is lack of information on the lumber recovery potential of aspen in the Rocky Mountains. To help provide this information, a very limited study at two mills was conducted under conditions that are typical of sawmills and logging operations cutting aspen in the Rocky Mountains.

Grading Systems

As part of the overall research effort on Rocky Mountain aspen, grading methods were evaluated that might prove useful in assessing the potential of standing aspen timber and saw logs for conversion into sawn wood products. One grading system selected for evaluation in this study was developed by Bailey (1973, 1974). This grading system is built around both tree diameter and quality. Because diameter is easier to measure in field situations, it was decided to test another simpler grading system based on tree diameter alone.

Two separate product classes were chosen for the evaluation: (1) 1-inch (2.5-cm) lumber graded with softwood grading rules, and (2) a combination of 2-inch (5-cm) dimension lumber and 4- by 6-inch (10- by 15-cm) mine timbers. Despite the fact that mine posts do not necessarily reflect grade quality, these product classes were selected because a previous review of the aspen problem in the Rocky Mountains indicated that market potential in the West for these products is higher than if aspen were used in more conventional hardwood products.[4]

Hardwood Tree and Log Grades

Tree and log grades developed and generally accepted for U.S. hardwoods are not appropriate for predicting lumber yields from aspen in the Rocky Mountains. Aspen lumber in the Rocky Mountains is now commonly graded, if at all, by softwood lumber rules and will likely continue to be, because it is sold and used mainly as a softwood. Another difficulty with using the standard hardwood grades is that aspen trees and logs in the Rocky Mountains fall almost entirely within the two lowest grades, which severely limits the value separation that can be obtained between the highest and lowest quality trees or logs. Because of the apparent incompatibility between the

[4] *In preparation for this study, Wengert contacted mill operators and others who utilized or marketed aspen products in the central and southern Rocky Mountains.*

purpose of the standard hardwood rules and the uses made of western aspen, other tree and log grading possibilities were explored.

Tree Grades

After studying various tree grades for assessing the potential of aspen in western Canada, Bailey (1974) developed some relatively simple grading rules that appeared to be effective. This study tested Bailey's grades for aspen in the Rocky Mountains.

Other relevant information about conk location and frequency came from two previous studies on aspen in Colorado (Hinds 1963, Hinds and Wengert 1977) that considered the influence of decay and *Phellinus tremulae* (= *Fomes igniarius*) on scaled tree volume. These latter studies indicated that aspen in the Rocky Mountains is most seriously affected by *P. tremulae* and, further, that the conks of this fungus are present and outwardly visible in 75% of the infections. To reflect the results of these studies, the tree grading rules developed by Bailey were modified to incorporate restrictions on the amount and location of conks (table 1).

The underlying philosophy of these tree grades is that d.b.h. is an indicator of both tree volume and of the probability of higher yields of upper grade boards usually obtained from larger trees. In contrast, conks and large scars indicate volume loss, especially in the lower sections of the merchantable bole where quality is normally expected to be higher, and quality loss from heavy staining.

Log Grades

Log grades used in this study for 8-foot (2.4-m) logs were Bailey's (1973), modified slightly by the authors (table 2).

Grades Based Only on Diameter

Because the mill phase of this study indicated that product volume and value were closely related to diameter, diameter was tested as a single parameter of value by regrading the trees and logs based only on the diameter limits of Bailey's rules (table 3).

Evaluation of Aspen Tree and Log Grades

Two methods of evaluating the effectiveness of log or tree grades were used in this study:

1. The ability to distinguish log or tree values (for example, dollar value per 100 cubic feet (2.83 m^3) or dollar value per unit of gross log scale).
2. The ability to distinguish the volume of lumber of particular grades (for example, the volume of No. 2 Common and Better in a diameter class).

Tree Selection

Trees were selected from two areas—the Carson National Forest near Taos, N. Mex., and the Uinta National Forest near Heber City, Utah. These were chosen, in part, because they represent two different market opportunities. Aspen from New Mexico is more accessible to eastern Rocky Mountain markets, including Albuquerque and Denver, for 1-inch (2.5-cm) lumber; aspen from Utah has a good potential for use in 2-inch (5-cm) lumber and posts for mines and other local markets. This difference in markets is reflected in the lumber sizes and grades manufactured (table 4).

The sampling plan was designed so that each modified tree grade category would be represented by the same number of trees. Trees were selected by starting

Table 1.—Trial tree grading criteria for aspen in the Rocky Mountains

Tree grade 1	Tree grade 2	Tree grade 3
d.b.h. 14 inches (36 cm) or greater with no conks and no scars more than 2 feet (61 cm) long in the lower 25 feet (7.6 m).	d.b.h. 10 to 13.9 inches (25 to 36 cm) with no conks and no scars more than 2 feet (61 cm) long in the lower 25 feet (7.6 m).	d.b.h. less than 10 (25 cm) inches with no conks and no scars more than 2 feet (61 cm) long in the lower 25 feet (7.6 m).
	---or---	---or---
	d.b.h. 14 inches (36 cm) or greater with limited conks,[1] or with scars more than 2 feet (61 cm) long, (scalable cull may run around 50%[2]).	d.b.h. (10 to 13.9 inches (25 to 36 cm) with limited conks,[1] or with scars more than 2 feet (61 cm) long, (scalable cull may run around 50%[2]).

[1]*Limited conks means either of the following conditions:*
a. Any number if all conks are below 16 feet (4.9 m) on the tree bole.
b. No more than three along the entire stem if any conks are above 16 feet (4.9 m) on the tree bole.
[2]*Not included in Bailey's tree grades.*

Table 2.—Trial tree grading criteria for aspen in the Rocky Mountains (8-foot logs)

Log grade 1	Log grade 2	Log grade 3
Straight logs, SED[1] 6 inches (15 cm) or greater, scalable decay less than 5%	Straight logs, SED 6 inches (15 cm) or greater, scalable decay 6% to 50%	Straight or sweepy logs, SED 5 inches (13 cm), scalable decay 0% to 50%
---or---	---or---	---or---
Sweepy logs,[2] SED 10 inches (25 cm) or greater, scalable decay less than 5%	Sweepy logs, SED 10 inches (25 cm) or greater, scalable decay 6% to 50%	Sweepy logs, SED 6 to 9 inches (15 to 24 cm), scalable decay 6% to 50%
	---or---	
	Sweepy logs, SED 6 to 9 inches (15 to 24 cm), scalable decay less than 5%	

[1]*SED = small end diameter, inside bark.*

[2]*Sweepy logs have a deviation of 1.5 to 3.5 inches (3.8 to 8.9 cm) between the main axis and a line connecting the centers of end areas. Straight logs have a deviation of less than 1.5 inches (3.8 cm).*

Table 3.—Trial grades for aspen trees and logs, based only on diameter

	Grade 1	Grade 2	Grade 3
Trees	d.b.h. 14 inches or over	d.b.h. 10 to 13.9 inches	d.b.h. less than 10 inches
Logs	SED[1] 10 inches or larger	SED 6 to 10 inches	SED less than 6 inches

[1]*SED = small end diameter, inside bark.*

Table 4.—Estimated 1975 prices for aspen lumber in the Rocky Mountains

Thickness and grade[1]	Dollars per thousand board feet
Manufactured in New Mexico	
1-inch, No. 2 Common or Better (boards)	212
1-inch, No. 3 Common (boards)	159
1-inch, No. 4 Common (boards)	132
1-inch, No. 5 Common (boards)	80
2-inch, Construction (light framing)	121
2-inch, Standard (light framing)	121
2-inch, Utility (light framing)	83
2-inch, Economy (light framing)	20
Manufactured in Utah	
1-inch, Construction (boards)	212
1-inch, Standard (boards)	159
1-inch, Utility (boards)	132
1-inch, Economy (boards)	80
2-inch, No. 1 (structural light framing)	121
2-inch, No. 2 (structural light framing)	121
2-inch, No. 3 (structural light framing)	83
2-inch, Economy (structural light framing)	20
Mine post, 4 by 6 inches	120

[1]*All grades except 4- by 6-inch mine posts are published by the Western Wood Products Association in "Grading Rules for Western Lumber" (annual editions). Sections 30.10 and 40.10 apply to New Mexico, and Sections 30.50 and 42.10 apply to Utah. Prices are for lumber graded when green.*

at one edge of the designated site and proceeding through the site to select the trees required to meet d.b.h. and grade requirements. Each tree was assigned a number.

After selecting and grading a tree, it was felled and bucked into haulable logs up to 33 feet (10 m) long in multiples of 8.25 feet (2.5 m). Lengths and diameters of logs were measured and recorded. Each log was numbered with respect to position in the tree and tree number.

Log Processing

After logs were hauled to the cooperating mill in New Mexico or Utah, they were bucked into 8.25-foot (2.5-m) lengths, renumbered, measured for diameter inside bark at both ends, scaled (Scribner), and graded using the modified Bailey log grade rules. Both mills sawed the logs with a circular-saw head rig. All lumber was tallied and, except for the mine posts at the Utah mill, graded green using Western Wood Products Association rules in effect in 1975. These rules permit grading of aspen as a softwood (Western Wood Products Association 1974). The New Mexico mill was sawing 1-inch (2.5-cm) lumber; however, the dog board[5] was always 2 inches (5 cm) and was not resawn.

At the Utah mill, 4-inch by 6-inch by 8-foot (10-cm by 15-cm by 2.5-m) mine posts were sawn from the smaller logs (less than 10 inches small end diameter) along with occassional pieces of 1- or 2-inch (2.5- or 5-cm) lumber. The larger logs were sawn only into 2-inch (5-cm) lumber with an occasional 1-inch (2.5-cm) board. This approach was used by the mill operator to improve recovery and profits, because mine posts can have heavy wane (which is likely when sawing small crooked logs), while 2-inch (5-cm) lumber grades are much less tolerant of wane. This practice results in high overruns for small logs.

Aspen Product Prices

To evaluate the grading systems, prices were estimated (table 4) at the time of the study on the basis of advice from USDA Forest Service personnel and mill operators in the two regions. All prices for aspen, except for the 4- by 6-inch (10- by 15-cm) posts, were lower than local conifer prices for the same product, reflecting a general lack of markets for aspen.

Evaluation Methods

Data for the study are separated and evaluated in four separate groups: Utah tree grades, New Mexico tree grades, Utah log grades, and New Mexico log grades. In addition, grades based only on log diameter were evaluated for each of the four data groups.

Data within each group were analyzed using analysis of variance and linear regression techniques. The four dependent variables examined were: (1) value of lumber from a log or tree per 100 cubic feet (2.83 m^3) of gross volume, (2) value of lumber from a log or tree per thousand board feet gross Scribner log scale, (3) percent of No. 2 Common and Better 4/4 lumber recovered from a log or tree, and (4) percent of No. 2 and Better 8/4 lumber recovered from a log or tree. The independent variables were the modified grades from Bailey, and the d.b.h. for trees or the small end diameter for logs.

No statistical analysis was made on several other variables for which data were taken and which are included in tables 5 and 7 for the reader's general information.

Analysis of variance (AOV) was applied to the data using the modified grades, or diameter, as the independent variable. Where the results of the AOV were significant, the practical inference is that grade, the independent variable, was an important determinant of value for the particular dependent variable.

Because the modified tree and log grades are closely related to diameter, the authors also investigated how diameter alone separates trees and logs into value classes. Thus, a statistically significant regression would support the hypothesis that the diameter of a tree or log could function as a single determinant of its quality or value.

Results and Discussion

At both sites, about half of the trees initially selected as grade 3 trees proved to be complete culls when felled. These trees were omitted from the mill sample and are not included in data summaries. This raises serious questions as to the adequacy or accuracy of the tree grade 3 criteria and indicates that supplementary techniques will be required to identify cull trees in cruising.

Tree Grades in Utah

Utah trees ranged in d.b.h. from 8 to 16 inches. The value per cunit of individual trees varied from $43 to $81, with an average value per cunit for all trees of $62. The AOV showed that tree grade did not conclusively separate trees into value classes based on dollars per cunit (table 5). The Utah mill mainly produced two distinctive products—mine posts from logs smaller than 10 inches in diameter and dimension lumber from logs 10 inches or larger in diameter. This distinction is important when interpreting the Utah data.

The value per gross thousand board feet of individual trees varied from $79 to $263. The mean values for each tree grade differed significantly from the others (table 5). It should be noted, however, that the value per gross thousand board feet increases with poorer grades. This is opposite to the relationship normally expected, and is explained by the fact that mine posts, a relatively high value product permitting wane and not

[5] *The dog board is the last board on the carriage in which the dogs (clamps) are inserted to hold the log during sawing.*

Table 5.—Summary of tree grade data for aspen in the Rocky Mountains

	Utah			New Mexico		
	1	2	3	1	2	3
Number of trees	6	17	11	9	24	19
Average value of trees, $/Cunit[1] (dollars per 2.83m³)	[2](57	64	62)	(92)	(74)	(55)
Average value of trees, dollars per gross thousand board feet (scribner log scale for merchantable trees	(106)	(141)	(206)	(163	148	135)
Average yield, No. 2 and Better dimension (percent of total lumber tally)	(42	29)	(10)			
Average yield, 4- by 6-inch (10- by 15-cm) mine posts (percent of total lumber tally)	6	24	56			
Average yield, No. 2 Common and Better (percent of total lumber tally)				(19)	(9	6)
Average yield, No. 3 Common and Better (percent of total lumber tally)				67	51	46

[1]Value of trees in dollars per Cunit (100 gross cubic feet) refers to those trees processed at the mill and does not include trees culled in the woods.

[2]Means separated by parentheses are significantly different, at the 95% statistical confidence level, than other means in the same group of three. No parentheses for a group indicates that no analysis was made.

necessarily reflecting grade quality, were sawn from the smaller trees. Many of these smaller trees are in grade 3, boosting recovery volume and value for this grade. This inverse effect is readily apparent when recovery for each product is compared on a tree grade basis (table 6).

The proportion of No. 2 and Better dimension lumber recovered, based on total lumber tally from individual trees, ranged from 0% to 67%. Most volume recovery of dimension lumber was from grades 1 or 2 trees (table 5). Smaller trees were mostly sawn into mine timbers (table 5).

Tree Grades in New Mexico

Tree d.b.h. for the New Mexico sample ranged from 8 to 17 inches. The value per cunit for individual New Mexico trees that yielded at least one 8-foot log ranged from $26 to $122. The differences in mean value for each tree grade were statistically significant, increasing as expected with better grades (table 5).

The value per gross thousand board feet of individual trees ranged from $58 to $285. The average lumber value per gross thousand board feet was $146. Mean values were not significantly related to tree grade (table 5). This is surprising in view of the significance noted in value per cunit. It probably resulted, especially in grade 3, from the poor estimates of product volume with the Scribner scale at small diameters.

The proportion of No. 2 Common and Better boards from individual trees, based on the total merchantable lumber recovered, ranged from 0% to 51%. The average recovery for grade 1 was significantly higher than for grades 2 or 3 (table 5).

Log Grades in Utah

Eight-foot logs from Utah ranged from 5 to 14 inches in small-end diameter. The value per cunit for logs ranged from a low of $3 for one typical grade 2 log to $130. The average value per cunit was $63. Log value per cunit was not significantly related to grade (table 7).

The value per gross thousand board feet of individual logs ranged from $10 to $470; the average value was $162. This large spread results from the relatively high value and volume recovery for mine posts. Also,

Table 6.—Proportion of lumber recovered by tree grade and product, Utah data

Tree grade	Diameter class range	Dimension lumber	Mine props
	inches	---------- *percent* ----------	
1	14-16	94	6
2	10-14	76	24
3	8-12	44	56

Table 7.—Summary of log grade data for aspen in the Rocky Mountains

	Utah			New Mexico		
	1	2	3	1	2	3
Number of logs	70	61	20	132	91	10
Average value of logs, dollars per Cunit[1] (2.83m³)	[2](64	63	56)	(81)	(58)	(42)
Average value of logs, dollars per gross thousand board feet (lumber tally) Scribner log scale	(148	177	167)	(166	156	125)
Average yield of No. 2 and Better (2 inch lumber compared with total yield, percent)	(36)	(19	13)			
Average yield of No. 3 and Better (2-inch lumber compared with total yield, percent)	65	47	25			
Average yield of No. 2 Common and Better (1-inch lumber compared with total yield, percent)				(12)	(4	0)
Average yield of No. 3 Common and Better (1-inch lumber compared with total yield, percent)				61	45	8
Average lumber recovery (log volume converted to lumber, percent)	50	52	56	49	20	38
Average chippable residue recovery (log volume converted to chips, percent)	38	39	41	36	47	51

[1]Value of logs in dollars per cunit (100 gross cubic feet).

[2]Means separated by parentheses are significantly different, at the 95% statistical confidence level, than other means in the same group of three. No parentheses for a group indicates that no analysis was made.

because of the special situation with respect to mine posts, value per gross thousand board feet was not significantly related to log grade (table 7).

The proportion of No. 2 and Better dimension lumber from individual logs ranged from 0% to 100%. The grade recovery from grade 1 logs was significantly higher than the recovery from grades 2 and 3 logs (table 7).

Log Grades in New Mexico

Eight-foot logs from New Mexico ranged from 5 to 16 inches in small-end diameter. The value of lumber per cunit from individual logs ranged from $6 to $148, with an average value of $70. The mean values for each grade were significantly different (table 7).

The value per gross thousand board feet of individual logs ranged from $16 to $412; the mean value was $160. There was no significant relationship to grade (table 7).

The proportion of No. 2 Common and Better boards from individual logs ranged from 0% to 68%. Grade 1 logs had significantly more recovery than grades 2 or 3 logs (table 7). Although the largest recovery value for individual logs is 68%, many logs yielded no boards graded No. 2 Common and Better; therefore, the mean values are low.

Diameter Alone as a Grade

Each of the independent variables in this study—the modified Bailey grades and diameter, both as a continuous and discrete variable—was evaluated on the basis of how much variation in the dependent variable is explained by the independent variable. A sum of squares analysis (table 8) was the technique for this evaluation. From the information in table 8, it appears that tree diameter grades function as well as the modified Bailey tree grades that incorporate both diameter and other quality factors. However, diameter

alone was not an effective variable for separating logs into various quality or value groups.

Summary and Conclusion

The log and tree grades evaluated in New Mexico for aspen being sawn primarily into 1-inch lumber were somewhat effective in separating logs and trees into distinct value and recovery classes. Only the value per cunit, however, reflected a statistical difference between all grades.

Table 8.—Proportion of total sums of squares (in percent) explained by classification of the sample data by grade or by diameter alone

	Grade groups, AOV	Diameter groups, AOV	Diameter, regression
Utah trees			
Value per cunit, dollars	NS[1]	NS	NS
Value per gross thousand board feet, dollars	51	58	55
Percent No. 2 and Better	28	32	52
New Mexico trees			
Value per cunit, dollars	NS	NS	NS
Value per gross thousand board feet, dollars	48	51	42
Percent No. 2 and Better	18	33	23

[1]Significance was determined both at the 5% and the 1% confidence levels. NS means not significantly different at either of these levels.

In Utah, tree grades also worked well for separating trees by recovery classes and by dollar value per gross thousand board feet lumber tally when mine timbers and 2-inch lumber were sawn, but tree grades did not work well for separating trees by value per cunit. Log grades worked well only for separating logs into dimension lumber recovery classes. They did not work well when mine props, a nongrade item, were the main product. As indicated previously, the results from Utah reflect the somewhat unique situation in which mine timbers, a relatively high value product permitting wane, were sawn from the smaller, lower grade trees instead of boards or dimension lumber. This product, which raised recovery volumes and values from the lower log grades, is not adequately reflected in the modified grading system.

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Wengert, Eugene M. and Dennis M. Donnelly. 1980. Lumber yield potential of aspen in the Rocky Mountains. USDA Forest Service Research Paper RM-227, 7 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

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Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

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Flagstaff, Arizona
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